Occurrence of an Introduced African Cichlid, the Blue Tilapia, *Tilapia aurea*, in a Tidal Creek of the Skidaway River, Georgia

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ABSTRACT.— The blue tilapia, *Tilapia aurea*, has not been reported previously from estuarine waters of Georgia. More than 35 juvenile blue tilapia were collected in a tidal creek on Skidaway Island, Chatham Co. Although it is not possible to determine the exact time and circumstances of the introduction, those specimens escaped from a raceway on Skidaway Island during the summer of 1989. The raceway system has been used for aquaculture experiments since the early 1970s, but recent changes in the drainage system (to provide for emergency containment of spills) may facilitate the establishment and spread of this population by warming water to the contained marsh, which enhances overwintering survival of this tropical species. The same traits of blue tilapia that are desirable for aquaculture have enabled the species to establish populations in a diverse range of habitats, including estuaries, in the southeastern United States. Deleterious effects of this species on some native fishes have been reported in Florida and Texas, and it seems prudent to eradicate the local population if possible.

An extensive review of the status of introduced fishes in the United States (Courtenay et al. 1984) listed the unconfirmed reports of *Tilapia aurea* (Steindachner) and *Tilapia mossambica* (Peters) on St. Simons Island and Sea Island (Glynn Co.) as the only reports of cichlid fishes in Georgia. This paper documents the first confirmed report of a cichlid in the state of Georgia.

Although it now occurs more widely across Africa, the blue tilapia, *T. aurea*, is native to Senegal; Middle Niger; Benue, Shari and Logone rivers; Lake Chad; the lower Nile from Cairo to the Delta Lakes; the Jordan River system; the Na'aman and Yarkon rivers of Israel; lakes Huleh and Kinnereth; Ein Feshkha; and the Dead Sea (Trewavas 1983).

This species is among the most widely distributed exotic fishes in North America, with populations now established in at least seven states (Courtenay et al. 1984). In the southeastern United States, the species has reproducing populations in Lake Julian, Buncombe Co., N. C., six Texas lakes, and more than 18 counties in Florida (Hubbs et al. 1978, Courtenay et al. 1984, Dolmon 1990). It is also established in Oklahoma, Arizona, California, and possibly Nevada (Courtenay et al. 1984). The species is widely used for control of aquatic vegetation (despite little if any demonstrated success), and its spread has been facilitated by the use of juveniles as bait (Courtenay et al. 1984).

Approximately 15 juvenile blue tilapia were collected by a local fisherman in minnow traps baited with blue crab (*Callinectes sapidus*) pieces in a tidal creek on the north end of Skidaway Island along the Skidaway River (Fig. 1). Unfortunately, the identity of the specimens

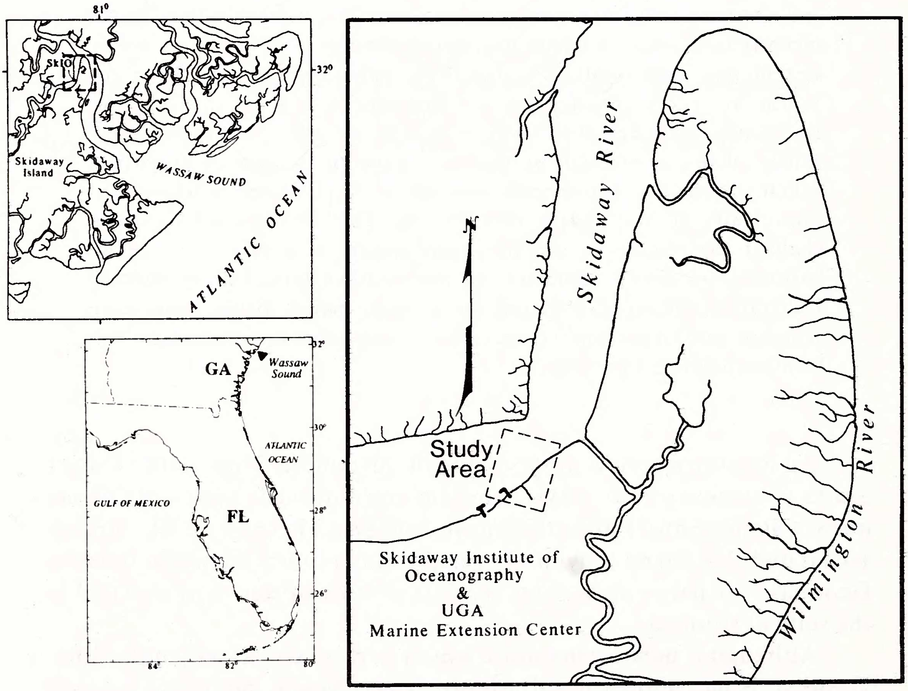

Fig. 1. Location of site where blue tilapia were collected. The figure on lower left shows the location of Wassaw Sound in Georgia, the figure on upper left shows the Skidaway Institute of Oceanography (outlined area in upper left corner), and the figure on right shows the location of the small, unnamed creek east of the laboratory docks in the Skidaway River.

was not known by the fisherman, who released most back into the Skidaway River. Examination of dead specimens, discarded as bait, established their identity as a species of cichlid. These specimens were kept for more detailed examination, which led to the study reported herein.

METHODS AND MATERIALS

To determine the extent of the distribution of blue tilapia in the area, numerous collections were made with five minnow traps, which were fished overnight in numerous places along the creek. Collections were also made with a cast net (2.4-m diameter, 1.2-cm mesh) in deep (>1 m) tidal pools. Daily collections with the cast net and minnow traps were made from 21 July to 3 August 1989. Temperature and salinity were recorded. All blue tilapia were placed immediately in 5% buffered seawater formalin. The occurrence of other species and their life history stages were noted; those specimens were then released alive. The tilapia were taken to the lab for processing.

All specimens were measured (total length, abbreviated as TL) on a measuring board to the nearest mm and weighed on an electronic balance to the nearest 0.1 g. An attempt was made to determine sex of the fish from macroscopic examination of gonads. Otoliths and scales were removed for possible age determination. Counts of dorsal fin rays and spines were made to ascertain the identity of the species (Trewavas 1983).

Voucher specimens have been placed in the collections of the University of Georgia Museum of Natural History (Athens, Ga.) and the Marine Extension Service Aquarium (Savannah, Ga.).

RESULTS

A total of 36 blue tilapia, ranging from 45 to 86 mm total length (mean = 65) and weighing from 1.7 to 11.9 g, were collected. The largest specimens were collected with cast net, but most specimens were collected in minnow traps. The length frequency distribution for all specimens is given in Fig. 2. All specimens exhibited the juvenile color pattern, consisting of 8 to 10 dark vertical bars from head to tail with a dark spot at the base of the soft portion of the dorsal fin. In most specimens, the maxillary and opercle were flecked with a metallic blue iridescence and the distal margin of the caudal fin was red. Counts of dorsal fin spines and rays ranged from 14 to 16 (mean = 15.4) and 12 to 13 (mean = 12.5), respectively, indicative of *T. aurea* and not a hybrid of *T. aurea* and *T. nilotica* (L.) (Trewavas 1983).

It was not possible to determine the sex of any individual from macroscopic examination. Gonads were barely visible to the naked eye.

Marks resembling annuli were not visible on the otoliths or scales of any specimens. The coloration, lack of gonadal development, and absence of annuli on any scales or otoliths suggest that all blue tilapia collected in the tidal creek were young of the year.

Temperature and salinity at this site were 20-29° C and 2-20 ppt, respectively. During at least two rainstorms (22-23 July and 9 August), salinity dropped below 1 ppt. Other species collected in this creek were American eel, *Anguilla rostrata* Lesueur; sheepshead killifish, *Cyprinodon variegatus* Lacépède; mummichog, *Fundulus heteroclitus* (L.); mosquitofish, *Gambusia affinis* (Baird and Girard); sailfin molly, *Poecilia latipinna* (Lesueur); striped mullet, *Mugil cephalus* L.; and freshwater goby, *Gobionellus shufeldti* (Jordan and Eigenmann).

DISCUSSION

A self-sustaining population of blue tilapia does not appear to be established at the present time; however, physiological characteristics of this species may facilitate its establishment in the Skidaway River. Although different measures of lethal temperature range from 6 to 12° C (Shaflund and Pestrak 1982, Zale 1984), the blue tilapia tolerates temperatures as low as 5° C in fresh water for brief periods (McBay 1961) and requires only 20° C for spawning (McBay 1961). Temperatures lower than 5° C seldom occur in the Skidaway River, and temperatures above the minimum for spawning occur from April through October in most years (D. Miller, University of Georgia Marine Extension Aquarium, personal communication). Blue tilapia are not only tolerant of high salinity, but also grow well and reproduce in brackish waters (Loya and Fishelson 1969, Trewavas 1983). In addition, blue tilapia are tolerant of poor water quality, including high ammonia (Redner and Stickney 1979). Conditions suitable for the growth and reproduction of blue tilapia are present throughout coastal waters of Georgia, including estuaries.

Although blue tilapia are not well studied in estuarine environments, other aspects of the ecology of the species appear conducive to its establishment in the Skidaway River. Mature individuals were not collected during this study, but ripe gonads have been observed in specimens as small as 58 mm standard length (Chervinski 1968). In Alabama ponds, females began to mature at 50 days and 10 cm TL (McBay 1961). Those conditions of maturity, the presence of potentially mature (> 58 mm SL) individuals in the Skidaway creek, and the favorable growing season in coastal Georgia indicate that establishment of a reproducing population in the Skidaway River estuary is a reasonable possibility. The blue tilapia is established in at least one Florida estuary, Tampa Bay (Courtenay et al. 1984).

Additional information about the feeding ecology, growth, and reproduction of blue tilapia in estuarine waters might indicate how such populations are established. Zale (1987) attributed the success of blue tilapia in fresh waters of the southeastern United States to the large eggs and large initial size of larvae; consequently, larval blue tilapia have foraging capabilities superior to those of larval centrarchids, which are smaller. The diet of blue tilapia in estuarine waters has not been reported, but the diet of blue tilapia in freshwater habitats includes phytoplankton, zooplankton, detritus, benthic invertebrates, and macrophytes (McBay 1961, Spataru and Zorn 1978, Hendricks and Noble 1979). Additional information on the biology of this species in estuarine waters is necessary before the critical factors in their dispersal and establishment in those habitats are understood.

The effects of blue tilapia on native aquatic communities are not well documented, but they are being reported with increasing frequency as this species spreads into new habitats and increases in abundance. Abundance of blue tilapia, approaching 2600 kg/ha in some waters of the United States (Noble and Germany 1976, Germany and Noble

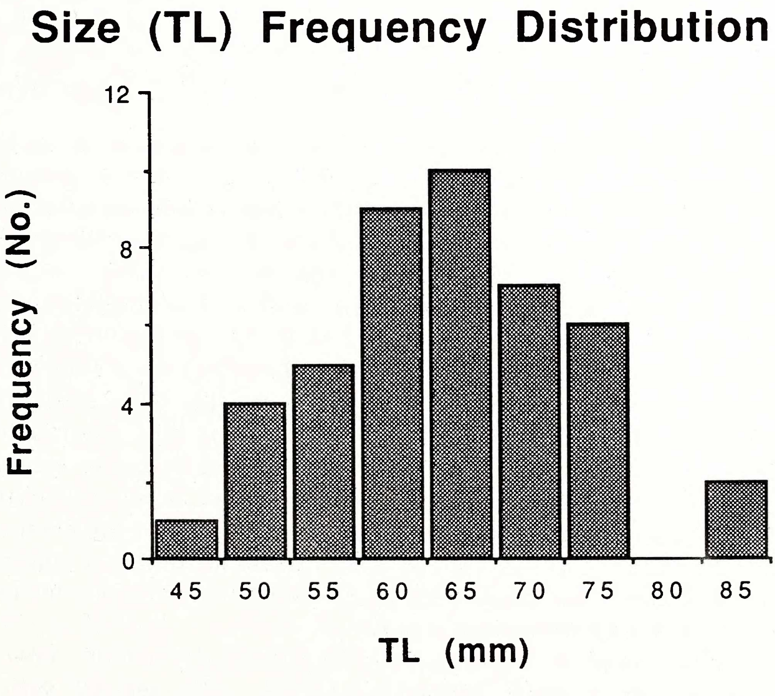

Fig. 2. Size distribution of blue tilapia collected with cast nest and minnow traps. Size categories given on the abscissa indicate the lower limit of a 5-mm category.

1977), has reached a point in many lakes of Florida and Texas at which it is adversely affecting reproduction of native centrarchids (Radonski et al. 1984, Taylor et al. 1984). The blue tilapia is the dominant species in cooling lakes at several power plants in Texas; several native fishes are scarce or absent in those lakes (Dolman 1990). *Tilapia aurea* has been reported to reduce the organic content of sediments, which eliminated blooms of the blue-green alga *Oscillatoria chalybea* in some Israeli reservoirs (Leventer 1981). The blue tilapia has been observed to depress populations of large phytoplankton and vulnerable zooplankton while enhancing small algae and evasive zooplankton (Drenner et al. 1984, 1987). Presumably through competition, the blue tilapia has been reported to reduce the catch of desirable fish in Lake Kinneret, Israel (Gophen et al. 1983, Vineyard et al. 1988). The effects on native fishes through removal of vegetation have not been documented (Taylor et al. 1984). The effects of blue tilapia on estuarine communities, including recreationally and commercially important fishes, have not been investigated. Given the inherent variability of the estuarine physical environment and an estuarine fish community that includes seasonal and transient members, demonstration of the adverse effects of blue tilapia on estuarine fishes is very difficult. This difficulty suggests that a conservative approach should be taken and that in the absence of demonstrated benefits, the reported population should be eliminated, if feasible.

Eradication of the Skidaway population may be possible given the present occurrence in only one tidal creek. The recorded juveniles escaped from a raceway on Skidaway Island that empties into the tidal creek. The raceway is one of two built in the early 1970s at the Skidaway Institute of Oceanography and has been used since its construction for aquaculture experiments and to hold surplus fishes. The drain in these raceways consists of an uncovered standpipe, from which raceway overflow dumps into a drainage culvert and a connecting tidal creek. Until the recent construction of the drainage culvert, the raceway overflow emptied directly into a tidal creek. With construction of the drainage culvert, runoff from several labs at Skidaway empties into the culvert, where it then drains into the tidal creek. Because of the form of this culvert and its tidal elevation, water from the lab does not flow immediately into the creek. In winter, these features may enhance overwintering survival in the creek by providing a large (approximately 13,000 liter) storage pool of warm water.

Eradication of the population may be possible through the application of rotenone or other ichthyocides to the small creek, but such a procedure has not been attempted. Modification of the raceway drain or elimination of the raceway population would prevent future introductions; however, initial attempts to remove the parent population have been unsuccessful. Unfortunately, runoff from recent storms (including Hurricane Hugo) may have already dispersed individuals to other parts of the Skidaway River estuary. Because of the mouth-brooding habits of this species, a single female, which can carry as many as 1,600 young (Payne and Collinson 1983), could disperse a considerable number of individuals to other parts of the river.

In summary, collections to date suggest that a substantial number of blue tilapia have escaped into a tidal creek of the Skidaway River. Whether or not the species is established in the Skidaway River estuary remains to be seen, but establishment appears both likely and unfortunate.

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